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THE PHYSIOLOGY OF THE AVIATOR[1]

DOUBTLESS you have all read the delightful historical accounts by the late Admiral Mahan of the great naval battles of the eighteenth century, when France and England struggled for the mastery of the sea. You will recall the stress laid on the weather gauge, or windward position. If the wind blew from the eastward, as does the "northeast trade" among the Caribbean Islands where a great part of the struggle occurred, whichever admiral was able so to maneuver as to be to the east of his enemy obtained a great, and often a decisive, advantage. He could choose the time and mode of attack, while his antagonist was compelled to remain on the defensive, unable either to force the fighting or to escape it.

In modern naval warfare the position of the sun in relation to the enemy's fleet affects the accuracy of aim. The speed of the ships is of importance equalling that of their gunfire. But there is no element of position which quite corresponds to that of the weather gauge for a fleet under sail.

In the battles of the ships of the air, however, there is again a condition which corresponds quite closely to the tactical advantage of maneuvering between the wind and the enemy. In this case it is not a direction in the plane of the horizon, except so far as light is important; but it is the direction at right angles, vertical to this plane. It is the upper position—the advantage obtained by him who can climb above his enemy, and, choosing the moment

[1] Address before the Harvey Society, New York City, March 22, 1919.

of attack, can swoop down upon him from above.

With this as one of the fundamental conditions of aerial warfare, it was inevitable that in the development of the battle plane there should be the utmost effort to produce machines of continually greater speed and, its correlative, climbing power. Likewise in the air, the greatest practicable altitude has meant for the flying man at once an advantage over his enemy and a reduction of his own chance of being hit by anti-aircraft fire from the enemy's guns on the ground.

Accordingly, from the comparatively low altitude at which the aerial fighting of the first year of the war usually occurred, the struggle rose, as more and more powerful airplanes were constructed by both sides, until at the end of the war it was quite common for battle planes to ascend to altitudes of 15,000 to 18,000 feet—three miles up, higher than the summits of the Rocky Mountains or the Alps.

Along with this development there occurred with increasing frequency among the aviators a condition of so-called "air-staleness." It is a condition closely similar to, perhaps identical with, the "overtraining" or staleness, the physical and nervous impairment of athletes in a football team or college crew. In the last year of the war this condition had become so common that, as reported to us by some observers, the majority of the more experienced aviators in the British service were incapacitated to ascend to the necessary altitude, and many could no longer fly at all. It was to make good this most serious military deficiency that the enlistment and training of aviators was undertaken by the American Air Service on the enormous scale that it was. It was for the purpose of testing our airmen initially, and of keeping tab on their physical condition thereafter, that the work at the Mineola laboratory, of which probably you have heard, was undertaken.

It is work which lies in a field of physiology in which before the war not half a dozen men in America, and not many more in Europe, were interested, and for them it was a field of what is called "pure" science. To-day it promises contributions of practical value not only to aviation, but to problems in medicine, climatology, athletics and hygiene.

We will turn then to the problem of the aviator and the methods of human engineering which have been developed for its solution. But first, it will be advisable to review briefly what is known concerning the immediate effects of low barometric pressure and the functional readjustments involved in acclimatization to elevated regions; that is, life at great altitudes.

Paul Bert,[2] the brilliant French physiologist, was the first to demonstrate, in 1878, that the effects of lowered barometric pressure or altitude are wholly dependent on the decreased pressure of oxygen. He carried out experiments upon men and animals both with artificial gas mixtures and reduced barometric pressure in a steel chamber.

He showed that in pure oxygen at 21 per cent. of atmospheric pressure life goes on in practically the same manner as in air, which contains 21 per cent. of oxygen, at the ordinary pressure. So also the breathing of an artificial gas mixture containing only 10.5 per cent. of oxygen has the same untoward effects at sea level that breathing pure air has at an altitude of about 20,000 feet, where the barometer is reduced by one half.

These considerations are fundamental for the differentiation of the disorders in-

[2] Paul Bert, "La Pression Barometrique," Paris, 1878.

duced by rarefied air—so-called mountain sickness—from the conditions resulting from work in compressed air—so-called caisson disease. It is clear that it is from the former, and not at all from the latter, that aviators suffer; but, as the two disorders are sometimes confused, a few words regarding the latter are in place here.

Caisson disease—known also as the "bends," "diver's palsy," and by other names—depends upon the fact that, under the high pressure necessary for diving, tunneling, and other work below water, the the nitrogen of the air dissolves in the blood and in the other fluids and tissues of the body in amounts proportional to the pressure. This in itself does no harm, and has in fact no effect upon the body, until the subject comes out of the pressure lock or caisson, or rises from the depth of the sea where he has been working. Then the nitrogen which has been dissolved begins to diffuse out of the body. This also does no harm and has no effect unless the pressure under which the man has been working is so high, and the lowering of the external pressure is so rapid, that the dissolved nitrogen separates in the form of bubbles. Such bubbles may form in the blood, in the synovial fluid of the joints, and even in the brain. They induce intense pain, and even paralysis and death. In order that bubbles may be formed it is essential, however, that the pressure with which the tissues are in equilibrium should have been lowered considerably more than half its absolute amount in a few seconds.

In the present state of the art of flying it is scarcely possible for an aviator to rise to a height of more than 20,000 feet, where the barometer would be less than half of that at sea level, in a period sufficiently short to allow bubbles of nitrogen to form in this way. The disorders from which aviators suffer are, therefore, of a different class from those to which workers in compressed air are exposed.

When the study of the effects of lowered barometric pressure was begun, it was supposed that the circulation might be primarily disturbed. The blood in the arteries of a healthy man is under such a pressure that, if a glass tube were inserted vertically into one of the arteries of his neck, and the blood were allowed to flow up the tube, the column of blood would come to rest at a height of 4 or 5 feet above his heart, corresponding to pressures of 120 to 150 mm. mercury. Knowing that the air pressure is reduced at great altitudes, some of the earlier writers made the mistake of supposing that such a column of blood would rise higher, and the blood vessels would be under a greater strain, and more likely to burst therefore, at a great altitude that at sea level. That which they looked for they found. One writer has left a lurid description of how, while crossing a pass in the Andes, he got off his mule and walked for a time to rest the animal. On the least exertion his breathing became oppressed, "his eyes bulged and his lips burst." The odd part of this is that in reality the blood vessels are under no greater strain at a high altitude that at sea level. When the air pressure upon the exterior of the body and in the lungs is reduced, a part of the gas —at least the nitrogen dissolved in the blood—rapidly diffuses out through the lungs, so that the gas pressure within and without the blood vessels are again equal just as at sea level. The idea is still prevalent that hemorrhages occur under low barometric pressures. However, among thousands of people whom I had an opportunity to observe on Pike's Peak during a five weeks stay at the summit, I saw not a single nose bleed, except one which was

caused by the forcible application of a hard object to the organ in question.

The only direct effects of changes of pressure are those which are felt in the ears, and occasionally in the sinuses connected with the nose. The ear drums are connected with the throat and contain air at the prevailing pressure. If the pressure is lowered this air expands, and forces its way out through the Eustachian tubes into the throat. If the outside pressure is increased, it sometimes happens, particularly when the subject has a cold and the Eustachian tubes are inflamed, that air does not pass readily into the middle ear. Accordingly the tympanic membranes are forced inward by the pressure; and this may cause acute pain. Workers in compressed air are accustomed, while going "into the air," *i. e.*, into pressure, to hold their noses and blow at frequent intervals as a means for expanding the ear drums. Aviators even during very rapid descents are generally relieved by merely swallowing.

To sum up all that has been said thus far, the influence of low barometric pressure is not mechanical but chemical. Life is often compared to a flame; but there are marked differences, depending upon the peculiar affinity of the blood for oxygen. A man may breathe quite comfortably in an atmosphere in which a candle is extinguished. The candle will burn with only slightly diminished brightness at an altitude at which a man collapses. The candle is affected by the proportions of oxygen and nitrogen. The living organism depends solely upon the absolute amount of oxygen—its so-called partial pressure.

Unlike the flame, a man may become acclimatized to a change of atmosphere in the course of a few days or weeks. He is thus adjusted to the mean barometric pressure under which he lives. Every healthy person is so adjusted, New Yorkers to a mean barometric pressure of 760 mm. no less than the inhabitants of Denver or Cripple Creek to their altitudes. Even your tall buildings could probably be shown to exert a slight climatic effect upon the tenants of the upper stories. The study of the processes involved in such acclimatization affords us one of the most promising means of analyzing some of the fundamental problems of life. In fact, is not the gaseous interchange of protoplasm, the carbon and oxygen metabolism of the cell, the central fact of life? Is not the mode of regulation of the interior environment of the body—the constants of the "humours"—the prime problem of the "vegetative" side of physiology.

Among the ill effects of lack of oxygen we may distinguish three more or less distinct conditions. They are comparable, in terms of more common disorders, to acute disease in contrast with chronic conditions of various degrees. Thus any one suddenly exposed to acute deprivation of oxygen, as is the balloonist or the aviator in very lofty ascents, shows one set of symptoms. If the exposure is less acute, as in the case of one taking up residence on a high mountain, the effects develop gradually; he passes through the stages of mountain sickness, a condition much like sea sickness, to a state of acclimatization and renewed health. If however the ascent or the flight is for only two or three hours, a period too short for any degree of acclimatization to develop, and this strain on the oxygen-needing organs is repeated daily, as is the case with the aviator of the upper air, the condition of "air staleness" is likely sooner or later to result. It is the effect of repeated slight oxygen deficiency on an individual who does not become acclimatized. It is, I believe, closely related to those effects of repeated over-exertion

and oxygen shortage which appear in the over-trained athlete.

The classic description of collapse from oxygen deficiency is that written by Tissandier,[3] the sole survivor of a fatal balloon ascent in 1875.

> I now come to the fateful moments when we were overcome by the terrible action of reduced pressure. At 7,000 meters (Bar. 320 mm.) we were all below in the car. . . . Torpor had seized me. My hands were cold and I wished to put on my fur gloves; but without my being aware of it, the action of taking them from my pocket required an effort which I was unable to make. At this height I wrote, nevertheless, in my notebook almost mechanically, and reproduce literally the following words, though I have no very clear recollection of writing them. They are written very illegibly by a hand rendered very shaky by the cold. My hands are frozen. I am well. We are well. Haze on the horizon, with small rounded cirrus. We are raising. Crocé is panting. We breathe oxygen. Sivel shuts his eyes. Croce also shuts his eyes. I empty aspirator. 1.20 P.M.,–11°, Bar. 320. Sivel is dozing. 1.25–11°, Bar. = 300. Sivel throws ballast. Sivel throws ballast. (The last words are scarcely legible.) . . . I had taken care to keep absolutely still, without suspecting that I had already perhaps lost the use of my limbs. At about 7,500 meters (Bar. 300 mm.) the condition of torpor which comes over one is extraordinary. Body and mind become feebler little by little, gradually and insensibly. There is no suffering. On the contrary one feels an inward joy. There is no thought of the dangerous position; one rises and is glad to be rising. The vertigo of high altitudes is not an empty word; but so far as I can judge from my own impressions this vertigo appears at the last moment, and immediately precedes extinction, sudden, unexpected and irresistible. . . . I soon felt myself so weak that I could not even turn my head to look at my companions. I wished to take hold of the oxygen tube, but found that I could not move my arms. My mind was still clear, however, and I watched the aneroid with my eyes fixed on the needle, which soon pointed to 290 mm. and then to 280. I wished to call out that we were now at 8,000 meters; but my tongue was paralyzed. All at once I shut my eyes and fell down powerless, and lost all further memory. It was about 1.30.

[3] Quoted from Paul Bert, *op. cit.*, p. 1061.

In this ascent the balloon continued to rise until a minimum pressure, registered automatically, of 263 mm. was reached. When Tissandier recovered consciousness Sivel and Crocé-Spinelli were dead. They were all provided with oxygen, ready to breath; but all were paralyzed before they could raise the tubes to their lips. Tissandier's notes are characteristic of the mental condition when oxygen-want is becoming dangerous.

In marked contrast to this condition is that of men who, gradually ascending into the mountains, day by day become acclimatized without realizing that any change has occurred. The record for the greatest altitude attained by mountaineers is held by the Duke of Abruzzi and his party in the Himalayas. They reached an altitude of 24,000 feet, where the atmospheric pressure is only two fifths of that at sea level, or practically the same as that at which Tissandier's companions lost consciousness. At this tremendous altitude the Duke and his Swiss guides were not only free from discomfort, but were able to perform the exertion of cutting steps in ice and climbing. Dr. Filippi, the physician who accompanied them, in discussing this matter says that the fact of their immunity admits of but one interpretation:

> Rarefaction of the air under ordinary conditions of the high mountains to the limits reached by man at the present day (307 mm.) does not produce mountain sickness.[4]

In this statement, however, he is certainly mistaken, for the observations of others show conclusively that the sudden exposure of unacclimatized men to an altitude considerably less than that reached by this party would either produce collapse like that of Tissandier's companions, or if long

[4] Quoted from Douglas, Haldane, Henderson and Schneider, "Physiological Observations on Pikes Peak," *Phil. Trans.*, 1913, B. 203, p. 310.

continued would result in mountain sickness. The latter effect especially is one which was the subject of careful study by an expedition of which I was a member, and which during the summer of 1911 spent five weeks at the summit of Pike's Peak, Colorado, altitude, 14,100 feet, Bar. 450 mm. We were there enabled to make observations upon hundreds of tourists who ascended the Peak, and who were acclimatized at most to the altitude of Colorado Springs or Manitou at the foot of the mountain. We saw a number of cases of collapse—fainting—from oxygen deficiency as shown by the striking cyanosis.

In the majority of cases, however, tourists who spent no more than the regulation half hour at the summit of the Peak, and then descended, experienced no acute ill effects. Headache and some degree of nausea were common even among these persons, however—often developing slowly for some hours after their descent. On the other hand, among persons who remained over night, and were thus exposed for several hours to deficiency of oxygen, the classic symptoms of mountain sickness occurred; and few escaped. Their second day at the summit was marked usually by extreme discomfort—headache, nausea, vomiting, dizziness and extraordinary instability of temper—symptoms which were strikingly exacerbated by even the smallest use of alcohol.

Our immediate party passed through these conditions and after two or three days, or in one case nearly a week, re-attained practically normal health. A definite functional readjustment had occurred. To illustrate and emphasize the nature of this readjustment I will quote a recent experiment[5] of my friend the leader of the Pike's Peak expedition, Dr. J. S. Haldane.

He has equipped his laboratory at Oxford with a small lead-lined chamber in which a man can be hermetically closed. The carbonic acid which he exhales is continually absorbed by alkali, so that no accumulation occurs, while the oxygen is progressively decreased by the breathing of the man himself. Dr. Haldane found that after a day or two in this chamber he had reduced the oxygen to an extent comparable to Pike's Peak. At the same time there had evidently occurred in himself a gradual process of adjustment, for he felt quite well. At this stage he invited another person to come into the chamber with him, and he had the satisfaction of observing the immediate development of blueness and the other symptoms of oxygen collapse in his companion.

Evidently acclimatization is a very real phenomenon and of the utmost importance to any one exposed to a lowered tension of oxygen.

As we observed it in ourselves during our stay on Pike's Peak acclimatization consists in three chief alterations: (1) increased number of red corpuscles in the blood; (2) some change in the lungs or blood (Haldane considers it the secretion of oxygen inward by the pulmonary tissue) which aids the absorption of oxygen, and (3) a lowering of the CO_2 in the alveolar air of the lungs. This lowering of the CO_2 in the lungs is bound up with increased volume of breathing. It is the concomitant of a decreased alkaline reserve in the blood just as in nephritis and diabetes. Acclimatization in this respect consists therefore in the development of a condition which would nowadays be called acidosis.

All of these changes are of a quantitative character. Miss FitzGerald[6] has supplemented the results obtained on Pike's Peak by an extensive series of careful observa-

[5] Personal communication.

[6] FitzGerald, M. P., *Phil. Trans.*, 1913, B. 203, p. 351, and *Proc. Royal Soc.*, 1914, B. 88, 248.

tions on the inhabitants of towns of closely graded altitude from sea level up to that of the highest inhabited place in our western country. She has thus shown that the mean hemoglobin and the mean alveolar CO_2 of the inhabitants of any town are functions of the mean barometric pressure of the place.

I shall not discuss pulmonary oxygen secretion now, because the problem is still extremely obscure; nor the increased production of red blood corpuscles, which is a slow process requiring weeks for completion, and playing no considerable part in the matter particularly before us.

We will fix our attention upon the fact that both the alveolar CO_2 of the pulmonary air and the alkaline reserve of the blood are reduced in accurate adjustment to any altitude, or oxygen tension, to which a man is subjected for a few days or even a few hours. This functional readjustment is, I believe, of great significance in relation to aviation, since it involves a larger volume of breathing per unit mass CO_2 eliminated: it thus compensates in part for the rarefaction of the air.

But how is it brought about? And why are the changes of breathing gradual, when the changes of altitude and oxygen tension are abrupt? The answer lies in part at least in the mode of development, and the nature of that acidosis of altitude to which I have referred. It is scarcely necessary to remind you that, as L. J. Henderson has shown, the balance of acids and bases in the blood, its C_H, depends upon the maintenance of a certain ratio between the dissolved carbonic acid, H_2CO_3 and sodium bicarbonate, $NaHCO_3$, or as Van Slyke terms it, the alkaline reserve. On the basis of this conception the prevalent view of acidosis is that, when acids other than carbonic are produced in the body, the bicarbonate is in part neutralized. The alkaline reserve is thus lowered, and the carbonic acid of the blood being now in relative excess, an increased volume of breathing is caused as an effort at compensation.

Recent investigations[7] by Dr. H. W. Haggard and myself show that an exactly opposite process is likewise possible. We find that whenever respiration is excited to more than ordinary activity, and the carbonic acid of the blood is thus reduced below the normal amount, a compensatory fall of the alkaline reserve occurs. The body is evidently endowed with the ability to keep the ratio of H_2CO_3 to $NaHCO_3$ normal, not only by eliminating CO_2 when the alkali is neutralized, but also by the passage of sodium out of the blood into the tissue fluid (or by some equivalent process) to reduce the alkaline reserve. A loss of CO_2 during over-active breathing is thus balanced. If it were not balanced a state of alkalosis would occur, which would inhibit and induce a fatal apnoea.

It is really in this way I believe that some of those conditions arise which nowadays are called "acidosis." If so they are not truly acidosis, or rather the process producing them is not acidosis, although the resultant condition gives some of the most characteristic tests of this condition. It is on the contrary a state, or rather a process, which Mosso was the first to recognize, although obscurely, and which he termed "acapnia" an excessive elimination of CO_2. Recent papers[8] from my laboratory have shown that a sudden and acute acapnia induces profound functional disturbances, including circulatory failure.

It is one of the well-known facts in physi-

[7] Henderson and Haggard, *Jour. Biol. Chem.*, 1918, 33, pp. 333, 345, 355, 365.

[8] Henderson and Harvey, *Amer. Jour. Physiol.*, 1918, 46, p. 533, and Henderson, Prince and Haggard, *Jour. Pharmac. Exper. Therap.*, 1918, 11, p. 189.

ology that deficiency of oxygen, or anoxemia, causes an "acidosis." Recent and as yet unpublished work of Dr. Haggard and myself indicates that the process involved is almost diametrically the opposite of that which has heretofore been supposed to occur, and that the result is not a true acidosis. Under low oxygen, instead of the blood becoming at first more acid with a compensatory blowing off of CO_2, what actually occurs is that, as the first step, the anoxemia induces excessive breathing. This lowers the CO_2 of the blood, rendering it abnormally alkaline; and alkali passes out of the blood to compensate what would otherwise be a condition of alkalosis.

We regard the current explanation, based on the production of lactic acid, as needing reversal.

The application of this idea to the changes of breathing and of the blood alkali in acclimatization clears up some of the points which heretofore have been obscure. Thus on Pike's Peak we saw that persons whose breathing under the stimulant of oxygen deficiency increased quickly to the amount normal for the altitude suffered correspondingly little, while those whose respiratory center was relatively insensitive to this influence suffered severely. The one type readily developed the acapnia and in consequence the pseudo-acidosis which the altitude requires. The other did not.

Here let me pause a moment to bring these conceptions into some degree of harmony with fundamental doctrines regarding respiration. For more than a century, in fact ever since the days of Lavoisier, the argument has been active whether our breathing is controlled by oxygen need or by the output of CO_2. For the past thirty years, and especially during the last ten or twelve, the theory of regulation by CO_2, or in its later form by C , has held the field. Indeed it is established now—almost beyond the possibility of contradiction, it would seem—that during any brief period of time, and under conditions to which the individual is accustomed, the amount of CO_2 produced in the tissues of the body, through its influence on the C_H of the blood, is the factor controlling the volume of air breathed. Its effects are immediate.

But when we view the matter more broadly it is clear that this is by no means the whole story. The oxygen tension of the air is the influence which determines just how sensitive the respiratory center is to excitement by CO_2. But the effects of any change of oxygen tension are slow in developing, requiring in some persons, as we saw on Pike's Peak, hours to begin and several days to become complete. In fact there are many perfectly healthy persons who, if caused to breathe progressively lowered tensions of oxygen down to 6 or 7 per cent. in the course of half an hour, feel nothing. Their breathing shows no considerable augmentation. They simply lose consciousness, and if left alone they would die, without any apparent effort on the part of respiration to compensate for the deficiency of oxygen. In such persons the stimulant of oxygen deficiency exerts only a slowly developing influence upon the sensitiveness of the respiratory center to the stimulus of CO_2. They can become acclimatized to great altitude only at the cost of prolonged mountain sickness. Evidently they are not suited to be aviators.

In very sensitive subjects, on the contrary, the period of readjustment is much shorter. It is a matter not of days but of hours, and the functional alterations begin to develop almost immediately even under slight oxygen deficiency. The upper air is for those men whose organization readily responds with vigorous compensatory reac-
gen.

With this inadequate sketch of present scientific knowledge regarding life at great altitudes as a background, we may turn to the application of this knowledge to the problems of human engineering in the aviation service of our army during the war. In September, 1917, I was appointed chairman of the Medical Research Board of the Air Service and was asked to lay out a plan for the development of a method of testing the ability of aviators to withstand altitude.

You will readily guess the line along which one would attack such a problem. It consisted in the development of an apparatus from which the man under test breathes air of a progressively falling tension of oxygen. The particular form which we use is called a rebreathing apparatus. It consists of a steel tank holding about 100 liters of air, connected with a small spirometer to record the breathing, and a cartridge containing alkali to absorb the CO_2 which the subject exhales. Breathing the air in this apparatus through a mouthpiece and rubber tubing the subject consumes the oxygen which it contains, and thus produced for himself the progressively lower and lower tensions of oxygen which are the physiological equivalent of altitude. To control and test the accuracy of the results with the rebreathing apparatus we installed in our laboratory at Mineola a steel chamber, in which six or eight men together can sit comfortably, and from which the air can be exhausted by a power driven pump down to any desired barometric pressure.

Such apparatus was however only the beginning. The practical problem was to determine the functional changes—pulse rate, arterial pressure, heart sounds, muscular coordination and psychic condition occurring in the good, the average and the poor candidates for the air service, and then to systematize and introduce these standards on a very large scale at the flying fields in this country and in France.

That this program was successfully carried through, and was approaching completion when the armistice was signed, was due chiefly on the scientific side to the brilliant work of my colleagues Majors E. C. Schneider, J. L. Whitney, Knight Dunlap and Captain H. F. Pierce, and on the administrative side to the splendid cooperation of Colonel W. H. Wilmer and Lieutenant Colonel E. G. Seibert.

We have recently published a group of papers,[9] brief but fairly comprehensive in their technical details, and I shall not now repeat what has there been said, but shall confine myself to a few salient points. One of these is a final and striking demonstration of our main thesis. Schneider and Whitney went into the steel chamber and the air was pumped out of it until the barometer stood at only 180 mm., 23 per cent. of the pressure outside: the equivalent of an altitude of 35,000 feet. Throughout the test they were supplied with oxygen from a cylinder through tubes and mouthpieces. They experienced no discomfort except from flatus: the gases of the stomach and intestine of course expanded nearly five fold.

In comparison with this observation is to be placed the recent record ascent by Captain Lang and Lieutenant Blowes in England to a height of 30,500 feet. They were supplied with oxygen apparatus; but a defect developed in the tube supplying Lieutenant Blowes and he lost consciousness. Captain Lang seems to have suffered only from cold.

From this it might appear that the

[9] Y. Henderson, E. G. Seibert, E. C. Schneider, J. L. Whitney, K. Dunlap, W. H. Wilmer, C. Berens, E. R. Lewis and S. Paton, *Journal American Medical Association*, 1918, Vol. 71, pp. 1382–1400.

simplest way to solve the problem of lofty ascents would be by means of oxygen apparatus. The Germans evidently made use of such apparatus, for it was found in the wreck of one of the German planes shot down over London. The British also had such apparatus, but it was difficult to manufacture, wasteful in operation, and in other respects left much to be desired. In fact the devising of such apparatus and its adaptation to the peculiar requirements of the human wearer are a problem which can be solved only by the close cooperation of a physiologist and a mechanical engineer. Mr. W. E. Gibbs, of the Bureau of Mines, with whom I had cooperated in developing mine rescue oxygen apparatus, took up this problem and produced a device which should prove valuable. Unfortunately the common tendency to favor ideas and apparatus coming to us from Europe operated against the adoption of the better American device.

It is doubtful however whether any apparatus of this sort will ever quite take the place of physical vigor and capacity to resist oxygen deficiency on the part of the aviator himself. Imagine him, when fighting for his life above the clouds, handicapped by goggles over his eyes, wireless telephone receivers on his ears, a combined telephone transmitter and oxygen inhaler over his mouth, and a padded helmet on his head!

The importance of determining the aviator's inherent power of resistance to oxygen deficiency, if he is to be even for a few moments without an oxygen inhaler, is demonstrated by the results of the routine examinations made with the rebreathing apparatus in the laboratory. These results show that 15 to 20 per cent. of all the men who pass an ordinary medical examination are unfit to ascend to the altitudes now required of every military aviator. On the other hand these tests pick out a small group of 5 to 10 per cent. who, without apparent immediate physical deterioration, withstand oxygen deficiency corresponding to altitudes of 20,000 feet or more.

It is particularly interesting to note that when the rebreathing test is pushed beyond the limit that the man can endure, be it the equivalent of only 10,000 or 25,000, two different physiological types with all gradations between them are revealed. The fainting type collapses from circulatory failure and requires an hour or two to recover. Often the heart appears distinctly dilated. The other and better type, on the contrary, goes to the equivalent of a tremendous altitude on the rebreathing apparatus and loses consciousness, becoming glassy-eyed and more or less rigid, but without fainting. When normal air is administered such men quickly recover.

Perhaps I ought to say at least a few words regarding the other aspects of the work at Mineola: for example the valuable psychological investigations and the controversy over the rotation tests, which has figured so largely in our medical journals of late. It seemed best, however, to confine myself this evening to my own special field. Nevertheless I can not suppress a public expression here of my sympathy for the brave and able scientific men in the psychological group at Mineola, who insisted on investigating the validity of the rotation tests. I am sure that you will feel as I do, when I tell you that they were threatened with punishmnet for insubordination when they refused to recognize that a regulation of the army, which prescribes the duration of nystagmus after the rotation test, necessarily makes this a physiological fact.

I would gladly devote a few minutes also to pointing out some of the lessons to be drawn from the rather unusually good opportunities which fell to my lot to observe

the mingling of science and militarism. The chief lesson can be put in a single phrase: They do not mix. The War Gas Investigations, which formed the nucleus on which the Chemical Warfare Service finally developed, and the Medical Aviation Investigations, of which I have spoken this evening, were both successful largely because at first they were developed under civilian control, under that splendid scientific arm of the government, the Bureau of Mines and its able director. It is a wise provision of our government by which the Secretary and Assistant Secretaries of War are always civilians. It would also be wise for the general staff in any future war to keep scientific men on a scientific status instead of practically forcing them into uniform.

We all hope that we are done with war, and with soldiers—at least for a generation. We can, however, derive certain broad lessons applicable to the conditions of peace from the experiences and intense activities of war, when almost unlimited funds were obtainable for research and the experiences ordinarily scattered over years were crowded into a few months. One of these lessons is that scientific men need to develop the capacity to become the heads of large enterprises without ceasing to be scientific, without degenerating, as is too often the case, into the super-clerk, who seems to be the American ideal of the high executive official. It is not enough for the scientific man to become the expert adviser to the unscientific administrator. If the latter has the responsibility he will use his power as he, and not as the scientific man, sees fit. To this rule I have known only one splendid exception.

For the most part among us the great prizes go to the man who works up through clerical rather than through expert lines. We must find some way to change this. The path of science must lead to the top, and at the top must still be science. To achieve this ideal, the scientist must show generosity toward colleagues and subordinates, an enthusiastic recognition of their merit and an abnegation of self-aggrandizement, no less than skill in plan and energy in execution. It is essential also that he should develop methods for conserving time and strength by assigning clerical work to clerks instead of becoming a clerk himself, in order that he may keep mind and desk clear for the really important things.

The Chemical Warfare Service was a success largely because the chief of the Research Division followed these principles as the spontaneous promptings of science and patriotism.[10] Medical research in aviation was productive just so long as it pursued a similar course.

He who charts this course, so that others may follow it through the pathless seas of the future, will make a great contribution to science, education, government, and indeed to nearly every phase of trained activity in America.

YANDELL HENDERSON
YALE UNIVERSITY

A NEW DEPOSIT OF URANIUM ORE[1]

HITHERTO the known deposits of radium-uranium ore of commercial importance in the United States have been confined to the carnotite fields of Colorado and Utah, and to a much smaller extent to the pitchblende of Gilpin county, Colorado. In the spring of 1918, a new uranium deposit was discovered at Lusk, Wyo., which is hundreds of miles from any other known fields, and which has proved to be the first isolated deposit of uranium ore to produce commercial quantities. The deposit at Lusk has now proved itself by the

[10] *Cf.* G. A. Burrell, *Journal of Industrial and Engineering Chemistry*, 1918, Vol. II., p. 93.

[1] Published with the permission of the director of the U. S. Bureau of Mines.

production of several carloads of ore containing about 3 per cent. U_3O_8.

The discovery was made quite by accident by Mr. Ross Lambert, of Casper, Wyoming. Having purchased some land near Lusk, without any reference to its mineral value, Mr. Lambert found on the ore dumps of a former silver mine which had been abandoned more than thirty years ago a mineral that attracted his attention by its peculiar yellowish-green color. Mr. Lambert had a complete analysis made of some picked specimens by Mr. W. L. Piers, of Denver, who reported among other things a content of uranium corresponding to more than 20 per cent. of U_3O_8.

In September, 1918, one of the writers had the privilege of visiting the deposit which is situated at Lusk, Wyo., on the Chicago and Northwestern Railway, about twenty miles from the eastern boundary of Wyoming, near the Nebraska-South Dakota intersection. Although considerable prospecting has been done in the region since Mr. Lambert's discovery, the uranium ore so far appears to be confined to a single hill about one quarter of a mile in circumference at its base and tapering up to a sharp conical top about 350 feet above the base. The hill was known by the Indians as Silver Cliff Hill, and still carries this name. It is about one half mile north of Lusk, and lies at the extreme eastern edge of the Hartville uplift. The uranium occurs entirely in quartzite which lies between mica schist and granite. The ore is marked by its extreme variations in appearance. The most typical variety is a greenish-yellow very intimately mixed with quartzite having well rounded grains resembling tapioca in structure and color. However, the predominance of other oxides can completely alter the color and appearance of the ore without the uranium content being affected. For example, a variety containing iron oxide has a rich chocolate-brown color, and yet contains 12 to 15 per cent. U_3O_8 in some cases. Predominance of greenish shades is due to the presence of copper carbonates. Other specimens are black with a glassy lustre, owing to a very intimate mixture of a small quantity of uraninite in the quartzite. In the absence of coloring by these extraneous oxides, the mineral approaches a canary yellow, resembling that of carnotite. In some cases, the colors are found absolutely different in a single piece of quartzite without its chemical composition or the uranium content differing in the various zones. This is due to the high coloring power of a slight predominance of one or the other oxides. A very small proportion of uraninite in the quartzite can color it almost a jet black.

It has been very difficult to obtain pure crystals of the uranium mineral itself suitable for purposes of identification. However, Drs. F. B. Laney and E. D. Larsen, of the U. S. Geological Survey have been kind enough to examine some specimens collected by one of the writers. Dr. Larsen's measurements of the optical properties indicate very decidedly that the mineral is identical with uranophane, a hydrated calcium silicate containing some barium and lead, to which the formula $CaO(UO_3)_2(SiO_2)_2.6H_2O$ has usually been assigned. It is readily soluble in acids. The chemical evidence of the writers does not show correspondence with this chemical formula, but further work, both chemical and optical, is desirable before more definite statements can be made about the crystal form or chemical composition. Dr. Laney's microphotographs of polished sections indicate that the uraninite in the quartzite was introduced subsequent to the deposition of the sandstone and replaced the cementing material, and to a less extent, the sand grains themselves. Dr. Laney believes the mineral is probably an oxidation product of uraninite (U_3O_8).

The chemical evidence of the writers on material not so pure as could be desired (about 80 per cent. pure) indicates that the soluble bases and acids account for each other without reference to the uranium oxide at all. This was taken to indicate the existence of a free higher oxide, probably UO_3. Since the occurrence of this oxide in nature has not been reported, if confirmed, it would con-

stitute a new mineral which it has been proposed to name "lambertite" for its discoverer. As already stated, the confirmation must await further chemical and optical evidence on pure crystals if obtainable.

The present development work of the property has not been sufficient to show how much uranium ore it can be expected to produce. The fact that it has already produced about 100 tons is very encouraging.

The writers have been much indebted by the courtesies extended by Messrs. Ross Lambert and H. A. Duncan, owners of the property, and by Messrs. E. D. Morimer and E. A. Dufford, who were in charge of the property at the time of the writer's visit. It is also an especially pleasant obligation to acknowledge the kind interest and valuable assistance of Drs. Laney and Larsen in the examination of this material.

S. C. LIND,
C. W. DAVIS

GOLDEN, COLO.,
March, 1919

SCIENTIFIC EVENTS

CONFERENCE ON HIGH SCHOOL BIOLOGY

AN educational conference on biology in New York City high schools was held under the auspices of the Brooklyn Botanic Garden, laboratory building, on Friday evening, April 4, 1919, Dr. C. Stuart Gager, director of the Botanic Garden, presiding. The meeting was the outcome of a symposium and conference on botanical education in secondary schools on March 11, under the auspices of the Torrey Botanical Club at the American Museum of Natural History. The conference was composed of members of the faculties of Columbia University, Barnard College, Brooklyn Training School, The Lincoln School of Teachers College, and the scientific staffs of New York Botanical Garden and Brooklyn Botanic Garden. The speakers of the evening included: Dr. R. A. Rexford, representing Dr. John L. Tildsley, associate superintendent of schools, in charge of high schools in New York City; Principals Bogart, of Morris High School (Bronx); Janes, of Boy's High School (Brooklyn); Low, of Erasmus Hall High School (Brooklyn), and Zabriskie, of Washington Irving High School (Manhattan), Principal Denbigh, of Packer Collegiate Institute (Brooklyn); Dr. Edgar A. Bedford, professor of biology in Stuyvesant High School (Manhattan), in charge of a class in general science at Hunter College; Dr. George C. Wood, president of the New York Association of Biology Teachers; Dr. James E. Peabody, chairman, Committee on Biology National Educational Association; Professor R. A. Harper, Torrey professor of botany, Columbia University, and Dr. Otis W. Caldwell, director of the Lincoln School of Teachers College.

The purpose of the meeting was to secure an expression of opinion primarily from administrative officials of New York City high schools as to the actual and possible value of elementary biology as a high-school subject—the proposed introduction of courses in general science and community civics in first year of New York City high schools created the possibility of the elimination or serious curtailment of biology.

It was the unanimous opinion of every speaker that biology, both in content and in educational discipline, contributes something essential in the preparation of young men and young women for citizenship, which is not afforded by any other subject and it was the expressed opinion of all the principals that the elimination or curtailment of general biology from the high-school course of study would be an educational mistake. All of the speakers emphasized the necessity of planning a content of the course so as to make a very intimate and obvious correlation with the everyday life of the individual.

The conference is considered by many as the most important meeting for the consideration of this question that has ever been held in New York City and the result was especially significant in view of a commonly expressed opinion—shown by this conference to be wholly erroneous—that many if not all of the high-school principals were opposed to the subject of elementary biology.

APPOINTMENTS AT HARVARD UNIVERSITY

The following promotions and appointments in the scientific departments are announced:

George David Birkhoff, professor of mathematics. A.B. (Harvard Univ.) 1905, A.M. (*ibid.*) 196, Ph.D. (Univ. of Chicago) 1907. Instructor in mathematics, 1907–09, University of Wisconsin; preceptor in mathematics, 1909–11, professor of mathematics, 1911–12, Princeton University; assistant professor of mathematics, 1912–19, Harvard University.

Cecil Kent Drinker, associate professor of applied physiology. S.B. (Haverford Coll.) 1909, M.D. (Univ. of Pennsylvania) 1913. Instructor in physiology, 1915–16, Johns Hopkins University; instructor in physiology, 1916–18, assistant professor of physiology, 1918–19, Harvard University.

Chester Laurens Dawes, assistant professor of electrical engineering. S.B. (Mass. Institute of Technology) 1909. Assistant in electrical engineering, 1911–12, instructor in electrical engineering, 1912–19, Harvard University; instructor in electrical engineering, 1916–19, Massachusetts Institute of Technology.

William Caspar Graustein, assistant professor of mathematics. A.B. (Harvard Univ.) 1910, A.M. (*ibid.*) 1911, Ph.D. (Univ. of Bonn) 1913. Instructor in mathematics, 1913–14, 1919, Harvard University; instructor in mathematics, 1914–16, assistant professor of mathematics, 1916–19, Rice Institute, Texas.

Lincoln Ware Riddle, assistant professor of cryptogamic botany. A.B. (Harvard Univ.) 1902, A.M. (*ibid.*) 1905, Ph.D. (*ibid.*) 1906. Austin teaching fellow in botany, 1905–06, Harvard University; instructor in botany, 1906–09, associate professor of botany, 1909–18, professor of botany, 1918–19, Wellesley College.

Frederick Albert Saunders, assistant professor of physics. A.B. (Univ. of Toronto) 1895, Ph.D. (Johns Hopkins Univ.) 1899. Instructor in physics, 1899–1901, Haverford College; instructor in physics, 1901–02, associate professor of physics, 1902–05, professor of physics, 1905–14, Syracuse University; professor of physics, 1914–19, Vassar College.

Bancroft Huntington Brown, A.M., instructor in mathematics.

Edward Smith Handy, A.B., Austin teaching fellow in anthropology.

Charles Andrew Rupp, Jr., instructor in mathematics.

Arthur Bliss Seymour, S.M., assistant in the cryptogamic herbarium.

Horace Greeley Perry, A.M., Austin teaching fellow in botany.

John Felt Cole, A.B., instructor in astronomy.

McKeen Cattell, A.M., Austin teaching fellow in physiology.

Neal Tuttle, A.M., Austin teaching fellow in chemistry.

THE NATIONAL ACADEMY OF SCIENCES

At the meeting of the National Academy of Sciences, which took place last week at Washington, the following officers were elected:

Home Secretary: Dr. Charles Greely Abbot, assistant secretary of the Smithsonian Institution.

Treasurer: Frederick L. Ransome, U. S. Geological Survey.

Members of the Council: Colonel John J. Carty, American Telephone and Telegraph Company; Dr. Henry H. Donaldson, Wistar Institute of Anatomy, University of Pennsylvania, and Professor Raymond Pearl, school of hygiene and public health, The Johns Hopkins University.

Members were elected as follows:

Professor Joseph Barrell, geologist, Yale University,

Professor Gary Nathan Calkins, zoologist, Columbia University,

Professor Herbert D. Curtis, astronomer, Lick Observatory, University of California,

Gano Dunn, electrical engineer, New York City,

Professor Lawrence J. Henderson, biologist, Harvard University,

Professor Reid Hunt, pharmacologist, Harvard University,

Professor Treat Baldwin Johnson, chemist, Yale University,

Professor W. J. V. Osterhout, botanist, Harvard University,

Dr. Frederick A. Seares, astronomer, Mount Wilson Observatory, Mount Wilson, California,

Professor William A. Setchell, botanist, University of California,

Major General George O. Squier, electrical engineer, chief army signal officer, Washington, D. C.,

Professor Augustus Trowbridge, physicist, Princeton University,

Professor Oswald Veblen, mathematician, Princeton University,

Professor Ernest J. Wilczynski, mathematician, University of California,

Professor Edwin Bidwell Wilson, mathematical physicist, Massachusetts Institute of Technology.

At the annual dinner of the academy, the Henry Draper Gold Medal was awarded to Charles Fabry, professor of physics at the University of Marseilles, France, and the Alexander Agassiz Gold Medal, established through funds provided by Sir John Murray, was awarded to Prince Albert of Monaco.

The program of the scientific sessions of the academy was printed in the issue of SCIENCE for last week.

SCIENTIFIC NOTES AND NEWS

AT the annual general meeting of the American Philosophical Society held on April 24, 25 and 26, the following were elected to membership: Robert Grant Aitken, Mount Hamilton, Cal.; Joseph Charles Arthur, Lafayette, Ind.; Edward W. Berry, Baltimore; James Henry Breasted, Chicago; Ulric Dahlgren, Princeton; William Curtis Farabee, Philadelphia; John Huston Finley, Albany, N. Y.; Stephen Alfred Forbes, Urbana, Ill.; Chevalier Jackson, Philadelphia; Dayton C. Miller, Cleveland; George D. Rosengarten, Philadelphia; Albert Sauveur, Cambridge, Mass.; William Albert Setchell, Berkeley, Cal.; Julius O. Stieglitz, Chicago; Ambrose Swasey, Cleveland.

COLONEL JOHN J. CARTY, chief engineer of the American Telegraph and Telephone Company, largely responsible for the communications of the American army during the war, has received the rank of commandant of the Legion of Honor.

AT the meeting of the New York Section of the Society of Chemical Industry on April 18, portraits were unveiled by Dr. Charles F. Chandler, of J. B. F. Herreshoff and E. G. Acheson, Perkin Medalists of 1908 and 1910, respectively.

DR. ROBERT KIRKLAND NABOURS, professor of zoology and curator of the natural history museum at the Kansas State Agricultural College, was elected president of the Kansas Academy of Science at its fifty-first annual meeting. Dr. Bernard M. Allen, of the University of Kansas, was elected vice-president, and Dr. W. E. White, also of the university, secretary.

MR. JAMES W. MCGUIRE, of the Coast and Geodetic Survey, has been appointed a member of the U. S. Geographic Board.

DR. W. N. BERG, captain in the Sanitary Corps, stationed at Camp Lee, has received his discharge from the Army and has returned to the Bureau of Animal Industry.

AFTER thirty years' service as chairman of the department of chemistry at Northwestern University, Professor A. Van Eps Young has retired to his farm in North Carolina as professor emeritus.

DR. H. L. CURTIS, of the Bureau of Standards, has gone for a three months visit to European laboratories to obtain data on the progress of certain war problems.

MURRAY P. HOROWITZ, of the Massachusetts Institute of Technology, has been asked to go to Oklahoma, by the Oklahoma Tuberculosis Association, in order to conduct health surveys this summer. Together with the surveys which were completed last summer, the work will represent a state-wide health survey.

THE one hundred and thirteenth annual meeting of the Medical Society of the state of New York was held May 6 to 8, in Syracuse, under the presidency of Dr. Thomas H. Halsted, Syracuse.

THE Paris Academy of Medicine has elected as national associates: Dr. Yersin, director of the Pasteur Institute of Nha-Trang and Dr. Delagenière of Mans.

KING ALFONSO of Spain has signed a decree awarding the Great Cross of the Civilian Order of Alfonso XIII. to Mme Sklodowska Curie, of the University of Paris.

AT the annual meeting of the Chemical Society, London, held on March 27, Sir James J. Dobbie was elected president in succession to Sir William J. Pope.

DR. L. A. BAUER sailed from Liverpool, April 12, for Cape Palmas, Liberia, where, assisted by Lieutenant H. F. Johnston, he will make magnetic and electric observations in connection with the solar eclipse of May 29 next. The duration of totality will be nearly 7 minutes at this station. Dr. Bauer expects

to return to London at the end of June. Lieutenant Johnston as soon as possible after the eclipse will rejoin the *Carnegie,* as second in command. During the war he was on duty with the Admiralty Compass Department at Slough, England.

The Montyon prize ($500) has been awarded by the Paris Academy of Sciences to Drs. Henri Guillemard and André Labat, of Paris, for their researches on asphyxiating gases.

The Adams Prize of the University of Cambridge has been awarded to Professor J. W. Nicholson, F.R.S., for an essay on "Diffraction."

According to the *Proceedings* of the Washington Academy of Sciences Dr. Olaf Andersen of the Mineralogical Institute, Kristiania, and Professor Sem Sealand, professor of physics and rector of the Technological Institute of Norway, at Trondhjem, have been visiting Washington.

Dr. J. N. Van der Vries has resigned his position as professor of mathematics at the University of Kansas to continue his work as secretary of the central district of the Chamber of Commerce of the United States, with headquarters at Chicago.

Professor Arthur A. Neish is giving before the Institute of Arts and Sciences of Columbia University four lectures on "Liquid air; chemistry and the war."

The annual joint meeting of the University of Pennsylvania Chapters of the Sigma Xi and Phi Beta Kappa Societies was held on May 1. The address was by Dr. William E. Safford, economic botanist, U. S. Department of Agriculture, former governor of the island of Guam, Pacific ocean, on "Plants in the arts and industries of the ancient Americans."

The Yale Medical Alumni Association Lecture for this year was given on April 4 by Dr. William Gilman Thompson, of New York, on the Functional restoration of the disabled soldier and civilian.

The Ramsay Memorial Committee has offered to the University of London a sum of not less than £25,000 towards the foundation of a laboratory of chemical engineering at University College.

Charles Brinkerhoff Richards, for twenty-five years Higgins professor of mechanical engineering at Yale University, and for the last nine years emeritus professor, died on April 20, in his eighty-sixth year.

Nature records the deaths of Sir James MacKenzie Davidson, the distinguished ophthalmic surgeon and radiologist, and of Dr. William Allen Sturge, author of papers on prehistoric ethnology.

R. W. H. Row, lecturer in zoology at King's College, London, died on February 16, at the age of thirty-four years.

The death is announced of Dr. K. H. v. Bardeleben, professor of anatomy at the University of Jena and author of a long series of works on anatomy and evolution at the age of sixty-nine years, and of Dr. R. Kobert, professor of pharmacology, physiologic chemistry and the history of medicine at the University of Rostock, an authority on materia medica and physiologic chemistry, aged sixty-five years.

The New England Federation of Natural History Societies held its annual meeting on April 25 and 26 in the Massachusetts Institute of Technology. This is a federation of some thirty societies of the New England states which has an annual gathering in Boston, at which the representatives of the different associations exchange experiences in matters of natural history. Delegates were present from Springfield, Mass.; Worcester, Mass.; Providence, R. I.; New Bedford, Mass.; Lawrence, Mass., and points in Maine and New Hampshire. There were exhibitions of various items in methods of handling specimens.

The American Astronomical Society will hold its annual meeting in Ann Arbor from September 1 to 3. It is announced that there will be in attendance at the conference, representatives from the observatories of Greenwich, Oxford, Cambridge, Vienna and Potsdam.

EDUCATIONAL NOTES AND NEWS

MR. AND MRS. WILLIAM FITZHUGH have given $12,000 to the medical school of Stanford University for the purchase of one gram of radium, for use in the actinography department of the University Hospital. The net income is to be used for clinic beds for indigent patients, particularly for those who need either X-ray or radium treatment.

THEODORE HOOVER, consulting engineer, has been appointed professor of mining and metallurgy in Stanford University.

PROFESSOR W. LEE LEWIS, of Northwestern University, has been elected chairman of the department of chemistry to succeed Professor A. Van Eps Young, who has recently retired. Captain Lewis was in charge of Organic Research Unit No. 3 of the Offense Research Section, C. W. S. during 1918 and is at present assisting Colonel W. D. Bancroft in editing the researches of the American University Experiment Station.

DR. GEORGE W. WILSON, of the Rockefeller Institute for Medical Research, has been appointed head of the department of pathology, bacteriology and preventive medicine in the Loyola University School of Medicine, Chicago.

JULIAN G. LEACH, of the University of Minnesota, has been appointed assistant professor of botany in the Colorado Agricultural College.

DISCUSSION AND CORRESPONDENCE

APROPOS OF THE PROPOSED HISTORICAL SCIENCE SECTION

IN the April 4 number of SCIENCE, page 331, Felix Neumann referred to a proposed "Historical Science" Section of the American Association for the Advancement of Science. If the feasibility of forming such a section is to be seriously considered during the meeting at St. Louis it would be of interest to know how the various sciences would probably be affected by this section. As regards mathematics, in particular, it is very difficult to say what is historical mathematics and what is non-historical mathematics.

As early as 1640 the famous French mathematician and philosopher R. Descartes wrote as follows:

> I am accustomed to distinguish two things in the mathematics, the history and the science. By history I mean what is already discovered, and is committed to books. And by the science, the skill of resolving all questions.

Since the days of Descartes the amount of mathematics committed to books has increased a hundredfold and hence the history of mathematics up to the present time has outgrown the powers of a single man.

Successful mathematical investigators must perforce be mathematical historians as regards their fields of investigation. If these fields are extensive the successful investigators therein require an extensive historical knowledge. Such men are, however, not commonly known as mathematical historians but as mathematical investigators. The former term is usually reserved for those whose historical studies include details relating to the older developments, which usually have little contact with modern advances.

The historical mathematics which is of greatest interest to the investigator engaged in advancing mathematics is usually based on considerable technical knowledge and hence it would scarcely be treated in a section composed largely of non-mathematicians. On the other hand, the historical mathematics which is now commonly known as mathematical history has extensive contact with the history of other sciences and might profitably be treated in such a section. The fact that the proposed name "Historical Science" would be too comprehensive as regards mathematics can scarcely be regarded as a serious objection since the questions which would normally come before such a section would naturally be determined by its membership.

In a broad way it might perhaps be said that the mathematical history suitable for such a general section might include practically all the useful developments in this subject before the beginning of the eighteenth

century, a considerable part of the developments during the eighteenth century, and a very minor part of later developments. The unequal emphasis which such a section would thus place on the different chapters in the history of mathematics would be partly compensated by the fact that it would prepare the way for a more sympathetic attitude towards mathematical history in general.

If such a section is formed it should be understood that the more technical and perhaps the more important part of the history of science is of such a nature that it can be appreciated only by the specialists in the fields to which it relates. There is, however, a great need for work on intercommunicating roads in science and such a section might tend to improve these roads.

G. A. Miller

University of Illinois

VITAMIN TESTS WITH CHICKS

Our experience recently with the use of chicks for the purpose of demonstrating to classes in elementary physiology the rôle of vitamins in a diet has been so satisfactory that we thought it might be of interest to other teachers.

The day-old chick is so universally available, so easily reared, and its growth is so rapid that it makes an admirable laboratory animal for such a demonstration. Because of their hardiness Leghorn chicks were selected and divided into two groups of equal number and weight. Both the control group and the one to be tested (such chicks being easily marked with dye) were placed in the same large cage with free access to water, grit, shell, etc. Both groups were allowed to partake freely from food kept in a feeder. The food thus accessible consisted of either highly milled corn-meal, crumbs of unleavened white flour bread, or cakes baked from rice flour, or combinations of any or all of these. Changes were frequently made so that the chicks ate readily of the food furnished. In addition to this the normal or control group was fed once a day with small amounts of food containing vitamins.

After the second day the curve of the daily average weights showed a marked difference between the two groups. After approximately two weeks the one group began to exhibit the typical symptoms of lack of vitamins. Death occurs so promptly in the young chicks after the onset of symptoms that care must be taken to at once feed the ailing chicks with vitamin containing food. Small amounts of milk, scraped apple, lettuce, etc., sufficed to cause prompt recovery with marked acceleration in the rate of growth.

We of course recognize that no new results have been achieved but felt that the method of demonstration was worthy of note.

R. J. Seymour,
E. P. Durrant

Ohio State University

QUOTATIONS

THE BRITISH AIR-FORCE ESTIMATES AND AERONAUTICAL RESEARCH

The development of military aviation has been one of the wonders of the war, but we have naturally been kept somewhat in the dark as to the exact extent of such development while the war was still in progress. The veil has now been lifted, and General Seely, in speaking on the Air Estimates in the House of Commons on March 13, has given us a striking summary of the progress made during the past four years. The fact that the expenditure on the Air Force has increased two-hundred-fold since the outbreak of hostilities is a sufficient comment on the enormous advances that have taken place in the aeronautical world. General Seely states that if the armistice had not been signed, this year's estimates would have reached the sum of £200,000,000—an amount which is practically four times our pre-war expenditure on the entire navy! Even with the signing of peace in sight the sum of £66,500,000 is asked for, in order to ensure the maintenance of the aerial supremacy which we have gained during the war.

It is exceedingly gratifying to note that the true value of research is at last being appreciated, and the specific provision of £3,000,000

for "civil aviation, experiments and research" will be welcome news to those who hope for the scientific development of commercial flying. General Seely further points out that this sum does not by any means represent the total amount that will be spent on research beneficial to the civilian aviator, since the results of experiments carried out for military purposes and paid for out of the Army Estimates will be equally available for the improvement of commercial machines.

The government has decided that it can not itself undertake commercial flying, but that it will do everything in its power to give encouragement and protection, and it is already announced that the Postmaster-General is prepared to give contracts to private firms which are able to offer approved machines for postal services. Moreover, the government will place most of the military aerodromes of the country at the disposal of civilian pilots for a small fee, and this alone should do much to encourage civilian flying.

In the course of his speech General Seely announced that an important invention in wireless telephony had recently been made, by means of which the wireless operator in an aeroplane was able both to send and to receive messages. It was possible during the war for the leader of a scouting aeroplane squadron to communicate with the others, but it was not practicable to receive an answer. A vacuum valve generator was employed to generate smooth oscillations in the hanging aerial, and a vacuum valve magnifier with a crystal rectifier was used as the receiver. The experimental apparatus was in use in pre-war days, but it required years of research to make it practical and trustworthy.—*Nature.*

SCIENTIFIC BOOKS

The Place of Description, Definition and Classification in Philosophical Biology. By PROFESSOR WILLIAM E. RITTER, in "The Higher Usefulness of Science and other Essays" (4th essay). Richard G. Badger. 1918, Pp. 105–136.

FEW of those who have sometimes harbored mild inward protests against the expansions of subjective biology implied in the organization and interpretation of many of the experimental researches of the day realize the cogency of their unexpressed protests. That accurate thinking regarding biological fundamentals is of first importance for the proper direction and development of biology, science and even of civilization itself is suggested by Professor Ritter in a significant article which has not received nearly the attention it deserves.

Summarily stated Professor Ritter's thesis is as follows: Taxonomy has by many been set aside "as marking a juvenile period in the life of biology"; this appraisal of taxonomy involves a monstrous fallacy; the dominance of individual scientists animated by this mistaken attitude toward systematic zoology and botany has led to unfortunate consequences, both in the development of science and in that of civilization itself.

In science it has given rise to a state of affairs in which the experimental method has been raised to the high place of an end in itself, and has apparently been the stimulus to an extreme of speculation which is perhaps best exemplified by the theoretical conceptions of the German Weismann. In philosophy it has led to the doctrine of the superman, best exemplified in the writings of the German Nietzsche.

On the basis of the assertion that "taxonomic research in both zoology and botany has for years, so far as it has been based on morphology exclusively, taken as one of its guiding principles *neglect nothing,*" Professor Ritter goes on to suggest that we can no longer properly restrict our dictum of "neglect nothing" to morphological attributes alone, "but must extend it to all attributes of organisms whatever—morphological, physiological, ecological, chemical and all the rest." He is of the opinion that a comprehensive review of the whole range of biological results won during the last twenty-five years indicates that each of the main provinces of research "contain differentia corresponding to the systems of classification previously established on the

basis of pure morphology," and says: "No biological phenomenon is adequately interpreted or dealt with experimentally, until it has been considered with reference to the place which the organisms to which it pertains hold in the system of classification." That is, no generalization about the reaction of a species to light, or its chromosomal characters for example, can be accepted as fully valid until compared with the reaction to light or the chromosomal characters of all the other species of the genus, etc. All biologists with extensive field experience will have been struck with the "individualness" in many respects of the distribution, behavior and habit of the different species studied. "Each kind of organism has a chemistry to some extent unique," says Professor Ritter. The same appears to be true of its behavior, ecology, physiology, distribution. Yet nothing is more common, in the literature of present day biology, than generalization for the entire animal kingdom (sometimes even including man), on the basis of the experimental study of a single organism, perhaps among the Protozoa, Insecta or Aves!

Dr. Ritter calls attention to a fact which seems to have been missed by not a few biologists particularly in the fields of cytology and biochemistry, namely, that work in the "analysis" or "causal analysis" of organisms, in so far as the work really has an objective basis, is nothing more than a part of the description of the organism. In other words, analysis and explanation are only species of the genus description. "The sooner it is borne in upon the minds of all students of living beings, no matter with what aspects of such beings they may be occupied, that they are engaged in the great task of describing and classifying the living world; and, so far as 'pure biology' is concerned, are doing nothing else, the sooner will objective biology get itself set off from subjective biology and the sooner will philosophical biology become purged of the many morbific growths which now impair its health and mar its beauty."

"Never more than in the present day," says Professor Ritter, "when experimental research has found so wide and lasting, and, on the whole, beneficent a hold in biology has there been need of fidelity to description and classification." The emphasis is not so much on the shortcoming or even the incompleteness of the experimental method as on the great need for researches which shall inform us as to the "normal behavior of normal organisms under normal conditions."

Probably few would be willing at this stage of scientific development to go all the way with Professor Ritter in his apparently thoroughgoing skepticism regarding some of the popular biological concepts of the day, *e. g.*, those of the "germ plasm" and the "fit"; and it is quite certain that his implication of a lack of regard for and appreciation of the orderliness and unity of living nature on the part of the dominant school of biologists of the day is not wholly justified; but the note of warning he sounds as to the tendency "to neglect everything except the one or a very few things which the experimenter must of necessity make the object of each special piece of work" is one which deserves emphasis.

There are signs of a growing realization on the part of scientific men that recent tendencies to minimize the importance of description and classification in biology are unhealthful; and that with this realization is associated a tendency to utilize in greater measure the natural history mode of philosophizing of which Professor Ritter speaks and which he so highly recommends.

The war has taught scientific men, philosophers and people generally, the overwhelming necessity for right thinking about life and living, if we are to avoid additional cataclysms in the future.

Walter P. Taylor
Bureau of Biological Survey

SPECIAL ARTICLES

TO CUT OFF LARGE TUBES OF PYREX GLASS

On a number of occasions I have heard the remark from instructors in physics and chemistry, who do most of their own glass blowing, that they are unable to "cut" off squarely

large tubes of pyrex glass. Small tubes, up to about 20 mm. in diameter, yield readily to the usual file mark.

A well-known method for cutting large tubes of common glass is to make a file scratch round the tube, apply one turn of an iron wire held taut, and then heat the same to redness by an electric current.

This method, however, without modification, fails when attempting to cut pyrex tubes. The glass will simply not crack, and if the heating is pushed the hot wire usually sinks into the glass and finally fuses under the intense heat.

I was surprised recently to find that if the iron wire is replaced by a nichrome wire, say, of no. 14 or 16 gauge, the tube may be *cut* off by the incandescent wire in the same manner that a cake of soap is cut in two parts by means of a string.

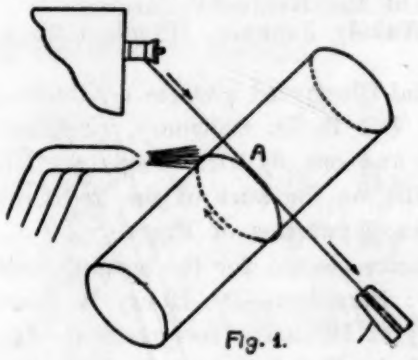

Fig. 1.

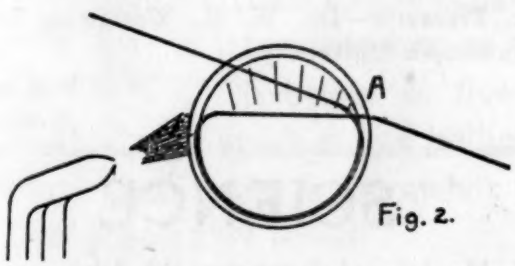

Fig. 2.

To insure success proceed as follows: Take a length of about one foot of nichrome wire, connect it up to a D. C. (or A. C.) dynamo current and include an adjustable tin resistance (for the current required must necessarily be large). The wire is held under tension by pulling on it with a pair of pincers, as shown in Fig. 1. Care must be taken not to let the two parts of the wire touch at *A*. When all is in readiness, turn on the heating current and adjust same by means of the tin resistance until the wire glows a white heat. If now a blast from a hand torch be allowed to play on the wire and glass the tube may be cut as shown in Fig. 2. Be careful not to let the flame strike the glowing wire where it is not in contact with the glass for the extra heat will burn it. The object of the blast is to aid in softening the glass, and also to distribute the heat along the tube and thus prevent the freshly cut edges from checking due to the otherwise intense local heating. The burr of glass that results from the cutting may be removed by a file or on the grindstone.

Recently the neck of a twelve-liter pyrex Florence flask was cut off with the greatest ease. The diameter was about 60 mm., and the wall thickness about 2.5 mm.

CHAS. T. KNIPP
UNIVERSITY OF ILLINOIS

THE ILLINOIS STATE ACADEMY OF SCIENCE

THE twelfth annual meeting of the Illinois State Academy of Science was held at Jacksonville, Ill., on March 21 and 22, having been postponed a month on account of the prevalence of influenza.

Important items of business transacted were the following: It was voted that the academy become affiliated with the American Association for the Advancement of Science, on the plan proposed by the committee on affiliations, of the American Association. It was voted that the academy become affiliated with the Division of State Museum of the Department of Registration and Education of the State Government. It was voted that the academy seek affiliated relations with science clubs in high schools, colleges and elsewhere in the state and a committee was appointed to perfect a plan for such affiliations. A committee on secondary-school science instruction was appointed. This committee is to make annual reports to the academy and to ask the aid and cooperation of the academy in its efforts to further the interests of such instruction. It was voted to offer for sale to libraries and individuals, full sets of the ten volumes of transactions now published at $5 per set.

Through the affiliated relation of the academy with the state museum, the former is practically guaranteed financial aid from the state for the

publication of its transactions. A bill providing one thousand dollars a year is now pending before the legslature, this item having been included in the budget submitted to the legislature by the governor.

The following is the program of papers and addresses presented at the meeting

PAPERS OF GENERAL INTEREST

Dr. H. S. Pepoon, Lake View High School, Chicago, "A proposed state park."

Dr. Chas. F. Millspaugh, Field Museum, Chicago, "Botany in a public museum."

Dr. Frank C. Baker, University of Illinois, "The Museum of Natural History of the University of Illinois."

J. L. Pricer, State Normal University, "Current tendencies in science education in the secondary schools."

William A. Dunkley, Geological Survey Division, "The use of central district coals in water-gas manufacture."

Gilbert H. Cady, Geological Survey Division, "The Illinois pyrite inventory."

Mr. F. E. Kempton, University of Illinois, "The Barberry Eradication Campaign."

REPORTS ON THE FORESTRY SURVEY OF ILLINOIS

Professor S. A. Forbes, State Laboratory of Natural History, "General plans and purposes of the survey."

Professor W. S. Waterman, Northwestern University; Professor H. C. Cowles, University of Chicago; Miss Hazel Schmoll, University of Chicago, "The survey of Cook County."

Dr. H. S. Pepoon, Lake View High School, Chicago, "Jo Daviess County."

Dr. George D. Fuller, University of Chicago, "La Salle County."

Mr. O. D. Frank, Quincy High School, "Adams County."

Dr. W. B. McDougal, University of Illinois, "Vermilion County."

Dr. Arthur G. Vestal, Eastern State Normal School, Charleston, "Cumberland County."

Symposium on Science and Reconstruction: The effects of the war on science and the opportunities and responsibilities of science under the new order of things.

Dr. Roger Adams, University of Illinois, "Chemistry."

F. W. De Wolf, Chief of Division of Geological Survey, "Geology."

Professor John M. Coulter, University of Chicago, "Botany."

Professor Henry B. Ward, University of Illinois, "Zoology."

Dr. C. St. Clair Drake, Chief of Department of Public Health, "Medicine and public health."

Dean Eugene Davenport, College of Agriculture, University of Illinois, "Agriculture and food production."

PAPERS ON BOTANY

Professor William Trelease, University of Illinois, "The scarlet oak of northern Illinois."

Professor Henry C. Cowles, University of Chicago, "Some floristic and ecological features of the woodlands of Cook County."

C. Z. Nelson, Galesburg, "Studies in the North American *Opuntia.*"

Dr. Geo. D. Fuller, University of Chicago, "Soil as a limiting factor of forests in La Salle County, Illinois."

Dr. W. B. McDougal, University of Illinois, "Some mushrooms which are rare or have not previously been reported from Illinois."

Clarence Bonnell, Harrisburg Township High School, "The occurrence of a white form of *Tradescantia virginica.*"

PAPERS ON ZOOLOGY

Dr. Frank C. Baker, University of Illinois, "A mussel survey of the upper waters of the Vermilion River, with special reference to Salt Fork."

Professor T. L. Hankinson, Eastern State Normal School, Charleston, "Life history notes on Illinois fish."

Dr. H. J. Van Cleave, University of Illinois, "Preliminary survey of the Acanthocephala from fishes of the Illinois River."

Theodore H. Frison, University of Illinois, "Keys for the separation of the Bremidæ, or bumblebees of Illinois, and other notes."

Miss Marion J. Miller, Illinois College, "Observation of the Kentucky Cardinal."

Anne Wakely Jackson, Illinois College, "Bird songs."

A special illustrated address on Porto Rico was given by Dr. R. D. Salisbury, president of the academy, and one by Dr. Josephine Milligan, of Jacksonville, on the work of the Red Cross among the civilian population of France.

The officers elected for the ensuing year are the following: *President*—Dr. Henry B. Ward, of the University of Illinois; *Vice-president*—Dr. Geo. D. Fuller, of the University of Chicago; *Secretary*—J. L. Pricer, of the State Normal University, Normal; *Treasurer*—Dr. W. G. Waterman, of the Northwestern University.

J. L. Pricer,
Secretary

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